

CHEMISTRY**Higher Grade—PAPER I**

Friday, 4th May—9.30 a.m. to 11.00 a.m.

READ CAREFULLY

1. Check that the answer sheet provided is for Chemistry Higher I.
2. Fill in the details required on the answer sheet.
3. In this paper a question is answered by indicating the choice A, B, C or D by a stroke made in INK in the appropriate place in the answer sheet—see the sample question below.
4. For each question there is only ONE correct answer.
5. Reference may be made to the booklets of Science Data and Mathematical Tables provided (1982 editions).
6. Rough working, if required, should be done only on this question paper, or on the rough working sheet provided—NOT on the answer sheet.

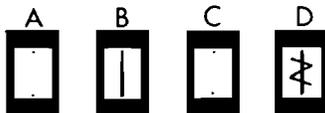
SAMPLE QUESTION

To show that the ink in a ball-pen consists of a mixture of dyes, the method of separation would be

- A fractional distillation
- B chromatography
- C fractional crystallisation
- D filtration.

The correct answer is B—chromatography. A **heavy** vertical line should be drawn joining the two dots in the appropriate box in the column headed **B** as shown on the answer sheet.

If after you have recorded your answer you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer **D** to an answer **B**, your answer sheet would look like this:



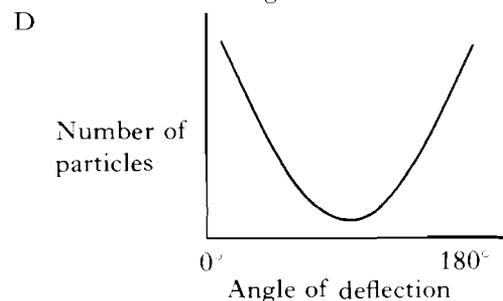
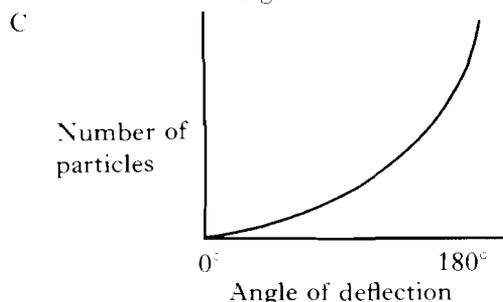
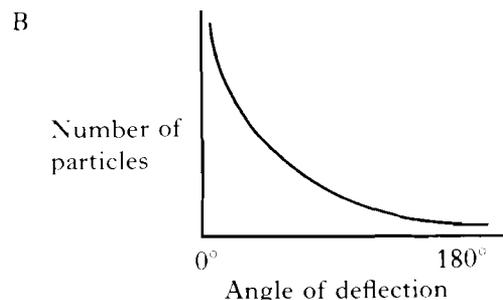
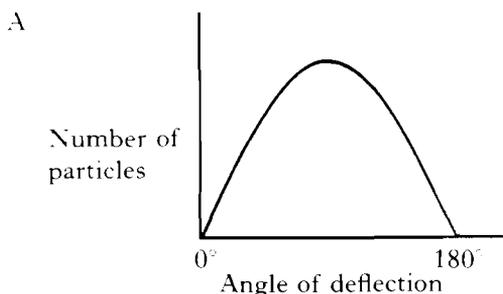
If you want to change back to an answer which has already been scored out, you should enter a tick (✓) to the **RIGHT** of the box of your choice, thus:



1. Isotopes have identical

- A nuclei
- B electron arrangements
- C numbers of neutrons
- D mass numbers.

2. Which of the following graphs could represent results from Rutherford's experiment, in which the existence of the nucleus was established by bombarding thin gold foil with alpha particles?



3. Which of the following exists as diatomic molecules?

- A Helium gas
- B Methane gas
- C Carbon monoxide gas
- D Crystalline sodium chloride

4. 152 g of an oxide of a metal X was strongly heated and hydrogen gas was passed over it. When the oxide was completely reduced, 104 g of metal X remained. If the relative atomic masses of the metal and oxygen are approximately 52 and 16 respectively, a possible formula for the oxide is

- A X_2O_3
- B XO_2
- C X_2O
- D XO

5. Which of the following statements is true about straight-chain alkanes?

- A Only the lower members burn.
- B They polymerise readily.
- C The melting points increase with molecular mass.
- D They form addition compounds with the halogens.

Questions 6, 7 and 8 refer to the following list of carbohydrates.

- A Glucose
- B Sucrose
- C Cellulose
- D Starch

6. Which has the molecular formula $C_6H_{12}O_6$?

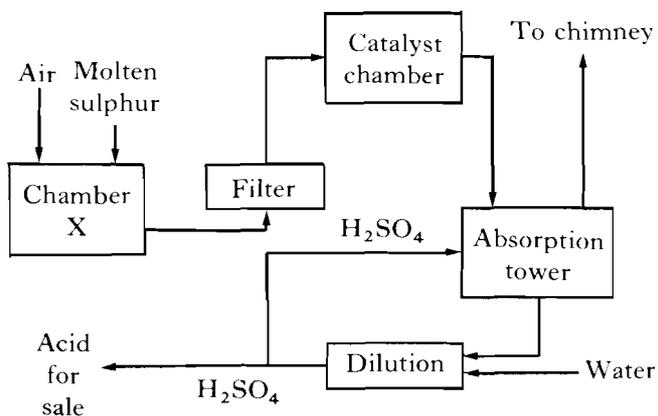
7. Which has reducing properties?

8. Which is an isomer of maltose?

9. Which of the following solutions is the best conductor of electricity?
- A 1 M sulphuric acid
 - B 2 M ammonia solution
 - C 2 M ethanoic acid
 - D 1 M sodium sulphate
10. Which of the processes outlined below is most likely to result in the production of magnesium?
- A Electrolysis of an aqueous solution of magnesium chloride
 - B The passing of hydrogen over heated magnesium oxide
 - C Electrolysis of molten magnesium chloride
 - D The addition of calcium to an aqueous solution of magnesium chloride
11. In which of the following reactions is the hydrogen ion an oxidising agent?
- A $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$
 - B $\text{NaOH} + \text{HNO}_3 \rightarrow \text{NaNO}_3 + \text{H}_2\text{O}$
 - C $\text{CuCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{H}_2\text{O} + \text{CO}_2$
 - D $\text{CH}_3\text{COONa} + \text{HCl} \rightarrow \text{NaCl} + \text{CH}_3\text{COOH}$
12. An iron nail is covered with water. Which of the following procedures would **not** increase the rate at which the iron nail corrodes?
- A Adding some sodium sulphate to the water
 - B Attaching a copper wire to the nail
 - C Passing carbon dioxide through the water
 - D Adding some glucose to the water
13. Which of the elements listed below has the following properties?
- (i) It can conduct electricity.
 - (ii) It burns in oxygen and a solution of the product has a pH less than 7.
- A Carbon
 - B Sodium
 - C Sulphur
 - D Aluminium
14. The gas evolved when dilute hydrochloric acid (2 M) is added to a mixture of copper turnings and copper(II) carbonate is
- A carbon dioxide only
 - B hydrogen only
 - C a mixture of hydrogen and carbon dioxide
 - D a mixture of carbon dioxide and chlorine.
15. The pH of a given solution is 5. Which of the following, when added to the given solution, would increase its pH?
- A Water
 - B 1 M hydrochloric acid
 - C Sodium chloride crystals
 - D 1 M ethanoic acid
16. An excess of silver nitrate solution is added to a solution of sodium chloride, and a white precipitate is formed. After filtering off the precipitate, which of the following reagents in solution would **not** give a precipitate when added to the filtrate?
- A Barium chloride
 - B Potassium nitrate
 - C Calcium hydroxide
 - D Sodium bromide

[Turn over

Questions 17 and 18 refer to the manufacture of sulphuric acid according to the flow diagram below.



17. Which of the following forms the largest proportion of the gas emitted from the chimney?

- A Nitrogen
- B Carbon dioxide
- C Water vapour
- D Sulphur dioxide

18. Which of these equations describes the main reaction taking place in chamber X?

- A $2S + 3O_2 \rightarrow 2SO_3$
- B $S + O_2 \rightarrow SO_2$
- C $2SO_2 + O_2 \rightarrow 2SO_3$
- D None of these

19. On which of the following properties of concentrated sulphuric acid does the preparation of nitric acid from potassium nitrate mainly depend?

- A It is an oxidising agent.
- B It is a dehydrating agent.
- C It has a high boiling point.
- D It is only slightly ionised.

20. When a mixture of nitrogen and hydrogen is burned in oxygen, which of the following compounds is formed?

- A Ammonia
- B Water
- C Nitric acid
- D Ammonium nitrate

21. Which of the following statements about ammonia is **false**?

- A It has a planar molecule.
- B It reduces copper(II) oxide.
- C It has hydrogen bonding between molecules in the liquid state.
- D It dissolves in water giving an increase in pH.

22. Which of the following tests could you use to distinguish between dilute nitric acid and dilute hydrochloric acid?

- A Find the pH of the liquid.
- B Add alkali and observe the change of conductivity.
- C Add zinc and test for hydrogen.
- D Add calcium carbonate and test for carbon dioxide.

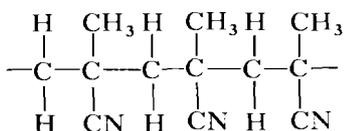
Questions 23 and 24 refer to the following types of chemical reaction.

- A Condensation
- B Hydration
- C Hydrolysis
- D Dehydration

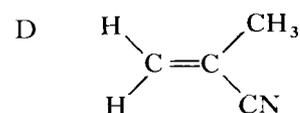
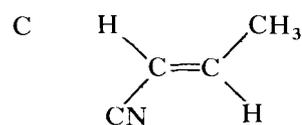
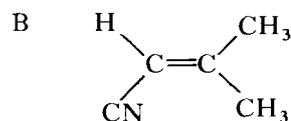
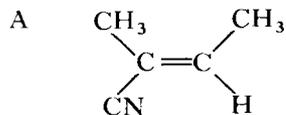
To which do the following processes belong?

- 23. The formation of ethanol from ethyl ethanoate
- 24. The formation of proteins from amino acids
- 25. Which of the following substances acts as a soap?
 - A Calcium stearate
 - B Stearic acid
 - C Potassium stearate
 - D Ethyl stearate

26.



Which of the following monomers could polymerise to give the above polymer?



27. Which would suffer the greatest deflection in a mass spectrometer?

- A ${}^1_0\text{n}$
 B ${}^1_1\text{H}^+$
 C ${}^1_1\text{H}_2^+$
 D ${}^4_2\text{He}^{2+}$

28. Naturally occurring nitrogen consists of two isotopes ${}^{14}\text{N}$ and ${}^{15}\text{N}$. How many types of stable nitrogen molecules will occur in the air?

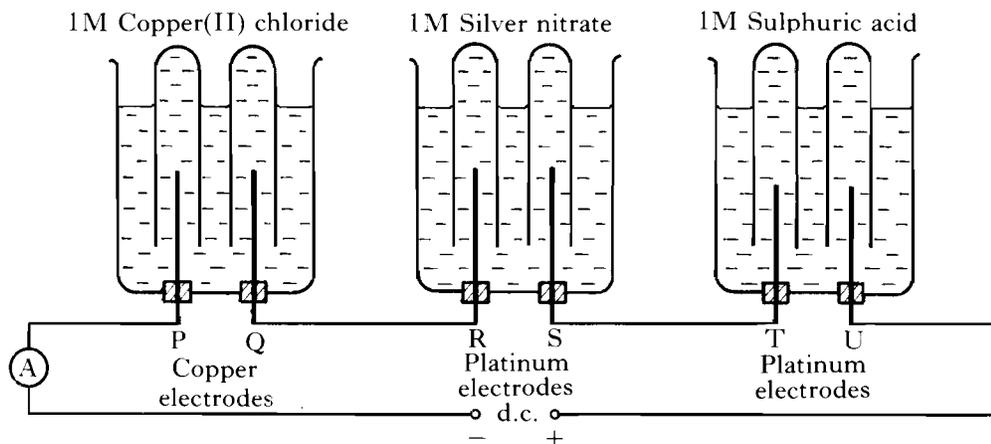
- A 1
 B 2
 C 3
 D 4

29. β -particles emitted by certain radioactive atoms are

- A electrons from the outer shell
 B electrons from the nucleus
 C particles consisting of 2 protons and 2 neutrons
 D electromagnetic radiations of very short wavelength.

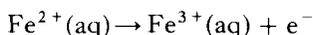
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Questions 30 and 31 refer to the following circuit, in which a steady current is maintained until 1.08 g of silver is formed on electrode R. All cells contain molar aqueous solutions.

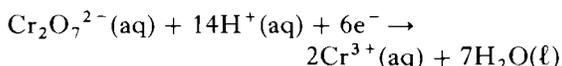


30. The time required to deposit the silver is 30 minutes. What would be the approximate reading on the ammeter?
- A 0.5 A
B 1.5 A
C 2.0 A
D 2.5 A
31. At which electrodes would identical products be obtained?
- A Q and U
B Q and S
C S and U
D At no pair are identical products obtained.
32. Given equal volumes of each gas, in which of the following pairs do both gases have the same mass at s.t.p.?
- A Hydrogen and helium
B Methane and oxygen
C Ethene and nitrogen
D Carbon monoxide and nitrogen monoxide
33. In the reaction
- $$2C(s) + O_2(g) \rightarrow 2CO(g)$$
- what mass of carbon is required to form 2.24 litres of CO at s.t.p.?
- A 0.6 g
B 1.2 g
C 6.0 g
D 12.0 g
34. A pupil obtained a certain volume of carbon dioxide by the action of 20 cm³ of 2 M hydrochloric acid on excess sodium carbonate. Which one of the following reagents would give the same final volume of carbon dioxide when added to excess sodium carbonate?
- A 20 cm³ 4 M hydrochloric acid
B 10 cm³ 4 M hydrochloric acid
C 20 cm³ 2 M sulphuric acid
D 40 cm³ 2 M hydrochloric acid
35. The mean bond dissociation energy of the C—H bond is 414 kJ mol⁻¹. From this information, it can be calculated that 1656 kJ of energy is
- A evolved when 1 mole of methane is burned in excess oxygen
B required to dissociate 1 mole of methane into free carbon and hydrogen atoms
C required for the complete combustion of 1 mole of methane
D evolved when 1 mole of graphite combines with 2 moles of hydrogen gas.

36. A cell is set up in which the following half reactions occur:



and



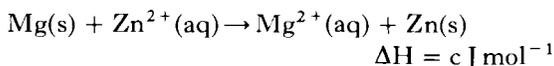
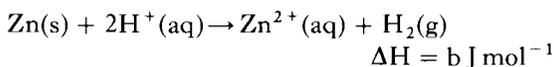
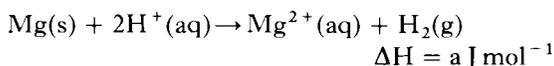
Under standard conditions, the cell voltage will be

- A $(1.33 + 0.77) \text{ V}$
 B $(1.33 - 0.77) \text{ V}$
 C $1/6(1.33 + 0.77) \text{ V}$
 D $1/6(1.33 - 0.77) \text{ V}$.

37. When a Group I metal atom X reacts to become an ion X^{+}

- A the diameter of the particle increases
 B the positive charge of the nucleus increases
 C the atomic number of X decreases
 D the number of occupied electron shells decreases by one.

38. Given the equations



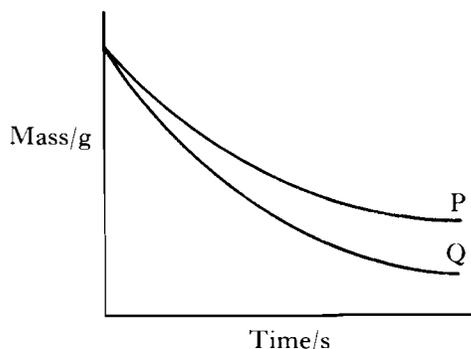
then, according to Hess's Law

- A $c = a + b$
 B $c = a - b$
 C $c = b - a$
 D $c = -b - a$

39. The lattice of caesium chloride has 8 chloride ions round each caesium ion, while that of sodium chloride has 6 chloride ions round each sodium ion. This difference in structure is due to the fact that caesium and sodium have different

- A electronegativities
 B ionic radii
 C electrode potentials
 D ionic charges.

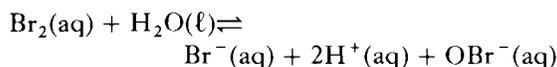
40. The course of the reaction between marble chips and dilute hydrochloric acid was followed by determining the mass of the reaction vessel and contents as carbon dioxide was evolved. The rate curves (P and Q) obtained under two different conditions are shown in the graph below:



The change in the form of the rate curve from P to Q would be obtained by

- A increasing the concentration of the acid
 B decreasing the temperature of the reactants
 C increasing the particle size of the marble
 D decreasing the volume of the acid.

41. Consider the equilibrium represented by

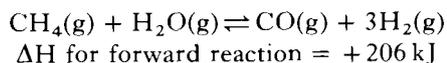


If excess sodium hydroxide solution were added, followed by dilute sulphuric acid, what would be observed?

- A Formation of a cream coloured precipitate, followed by its disappearance
 B Evolution of bromine vapour, followed by decolourisation
 C Disappearance of the original colour, followed by its reappearance
 D Intensification of the original colour, followed by evolution of gas

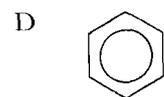
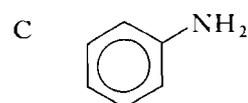
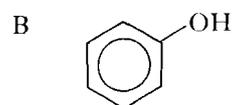
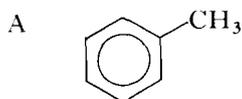
[Turn over

42. To obtain **hydrogen** in the process below, what would you predict to be the best conditions?



- A High temperature, low pressure
 B High temperature, high pressure
 C Low temperature, low pressure
 D Low temperature, high pressure
43. Which of the following dissolves in water to give an alkaline solution?
- A Sodium nitrate
 B Barium sulphate
 C Ammonium chloride
 D Potassium ethanoate
44. The substance of molecular formula $\text{C}_2\text{H}_6\text{O}_2$ which is formed when 1,2-dichloroethane is boiled with dilute alkali is
- A an ester
 B a alkanone
 C an acid
 D an alcohol.

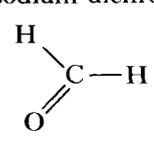
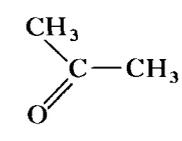
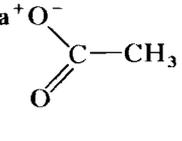
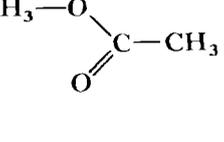
45. Which of the following will dissolve in sodium hydroxide solution?



- Questions 46 and 47 refer to the following types of reaction.

- A Addition
 B Hydrolysis
 C Dehydration
 D Substitution

Which one occurs in the following cases?

46. Propanol vapour + heated aluminium oxide
47. The "hardening" of vegetable oil
48. Which compound has formula mass 82?
- A Hexane
 B Hexene
 C Hexyne
 D Benzene
49. Which of the substances represented by the structures below would be expected to be **insoluble** in water?
- A $\text{CH}_3\text{CH}_2\text{COOH}$
 B $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$
 C $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_3^+\text{Cl}^-$
 D $\text{CH}_2\text{OHCHOHCH}_2\text{OH}$
50. Which of the following could be prepared by refluxing a secondary alkanol with excess acidified sodium dichromate solution?
- A 
- B 
- C 
- D 

[END OF QUESTION PAPER]

[0519/305]

1990

SCOTTISH CERTIFICATE OF EDUCATION

CHEMISTRY

Higher Grade—PAPER II

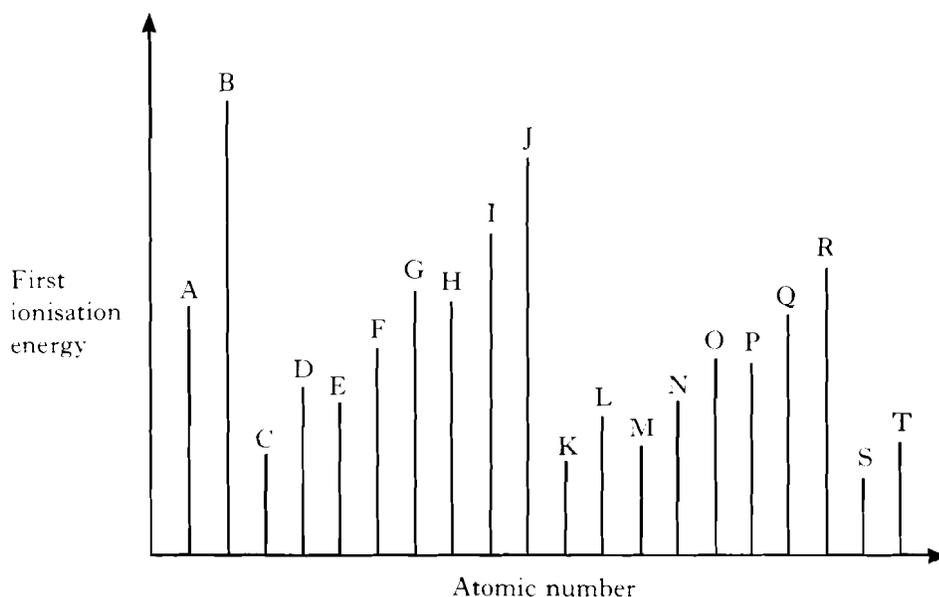
Friday, 4th May—1.30 p.m. to 4.00 p.m.

Candidates are reminded that 4 marks are allocated for communication skills, assessed mainly in Part B of this paper.

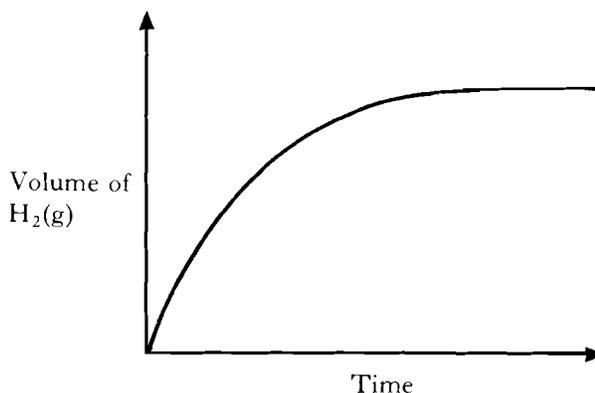
Working should be shown in all answers involving calculations.

Necessary tables and data will be found in the booklets of Mathematical Tables and Science Data (1982 editions).

5. The diagram shows the first ionisation energies of successive elements (A–T), plotted against their atomic numbers.



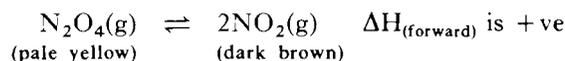
- (a) Which Group of elements is represented by the letters B, J and R? 1
- (b) Why is the first ionisation energy of element L greater than that of element K? 1
- (c) Why is the **second** ionisation energy of element L considerably less than that of element K? 1
- (3)**
6. Excess zinc was added to 2M sulphuric acid at room temperature, and the volume of hydrogen produced was plotted against time as shown.



- (a) Why does the gradient of the curve decrease as the reaction proceeds? 1
- (b) Copy the graph into your answer book (no graph paper required) and add the corresponding curves obtained when the reaction is repeated
- (i) at a higher temperature;
- (ii) using an equal volume of 1M sulphuric acid instead of 2M.
- (Label each curve carefully.)** 2
- (3)**

7. Answer **EITHER A OR B**.

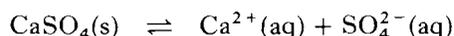
A. Consider the following equilibrium:

What would be **seen** if the equilibrium mixture was

- (a) placed in a freezing mixture; 1
- (b) compressed? 1
- (2)**

OR

B. Calcium sulphate is only sparingly soluble in water. It forms an equilibrium mixture in water as follows:



What would be the effect on the equilibrium mixture of adding

- (a) dilute sulphuric acid; 1
- (b) aqueous barium chloride? 1
- (2)**

8. In a series of experiments to determine the standard reduction potentials of various half-cells, the following results were obtained:

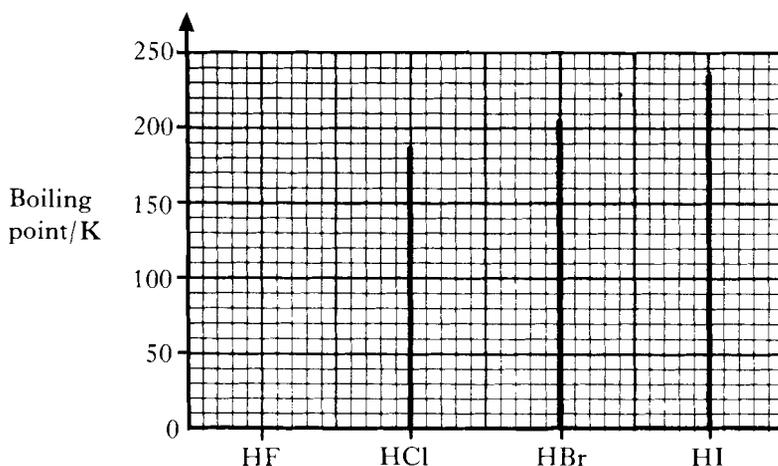
<i>Half-cell reaction</i>	<i>Potential/V</i>
$\text{P}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{P}(\text{s})$	+0.34
$\text{Q}^+(\text{aq}) + \text{e}^- \rightarrow \text{Q}(\text{s})$	-2.92
$\text{R}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{R}(\text{s})$	-0.76
$\text{S}^+(\text{aq}) + \text{e}^- \rightarrow \text{S}(\text{s})$	+0.80

- (a) Which of the metals P, Q, R or S is the most powerful reducing agent? 1
- (b) Which of the ions P^{2+} , Q^+ , R^{2+} or S^+ is the most powerful oxidising agent? 1
- (c) If pieces of tin were placed in molar aqueous solutions of all four ions, in which case(s) would the tin become coated with another metal? 1
- (d) Calculate the voltage (under standard conditions) obtained from the cell:



9. (a) Write balanced equations for the reactions occurring between sulphur dioxide and
- (i) aqueous sodium hydroxide; 2
- (ii) bromine water. 2
- (b) In each case, state the property of sulphur dioxide illustrated. 2
- (4)**

10. The diagram illustrates the trend in the boiling points of the Group VII hydrides HCl, HBr and HI.



- (a) Why is the boiling point of HI higher than that of HBr? 1
- (b) Estimate a value for the boiling point of hydrogen fluoride (HF), **if it were to follow this trend.** 1
- (c) The actual boiling point of HF is 292 K. Account for this unexpectedly high value. 1
- (d) Concentrated sulphuric acid does not react with hydrogen chloride; but, with hydrogen bromide, free bromine is formed along with water and sulphur dioxide.
- (i) Write a balanced equation for this reaction. 1
- (ii) What information does this provide concerning the relative oxidising or reducing powers of hydrogen chloride and hydrogen bromide? 1
- (5)**

[Turn over

11. Answer **EITHER A OR B**.

A. Consider the types of reactions and processes shown in boxes A to H.

A	B	C	D
Hydration	Reduction	Hydrolysis	Cracking
E	F	G	H
Treatment with steam and a catalyst	Condensation polymerisation	Treatment with hydrogen and a catalyst	Addition polymerisation

Answer the questions which follow by giving the box reference letter.

- (a) Which box refers to the formation of glucose from starch? 1
- (b) Which **two** boxes refer to the formation of ethanol from ethene? 2
- (c) Which box refers to the manufacture of PVC? 1
- (4)**

OR

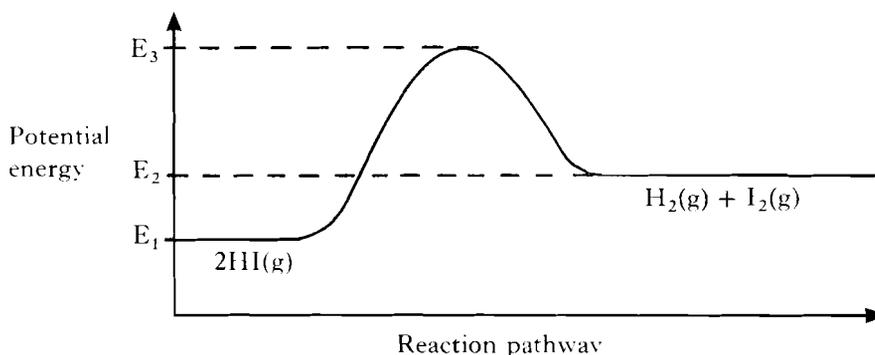
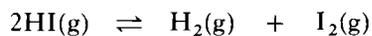
B. Consider the reactions which occur between the reactants shown in boxes P to U.

P	Q	R
$C_2H_5OH(\ell)$ + $C_3H_7COOH(\ell)$	$C_2H_4(g)$ + $H_2O(g)$	$CH_3CHO(g)$ + $CuO(s)$
S	T	U
$C_2H_5OH(\ell)$ + $Na(s)$	$CH_3COOC_2H_5(\ell)$ + $NaOH(aq)$	$C_3H_7OH(\ell)$ + $C_2H_5COOH(\ell)$

Answer the questions which follow by giving the box reference letter.

- (a) Which **two** reactions give an alkanol as a product? 2
- (b) Which reaction gives a product of pH less than 7 in aqueous solution? 1
- (c) Which **two** reactions give products which are isomers? 1
- (4)**

12. The potential energy diagram refers to the process:



(a) In terms of E_1 , E_2 and E_3 , state

(i) the activation energy of the reaction



(ii) the enthalpy change for the reverse reaction



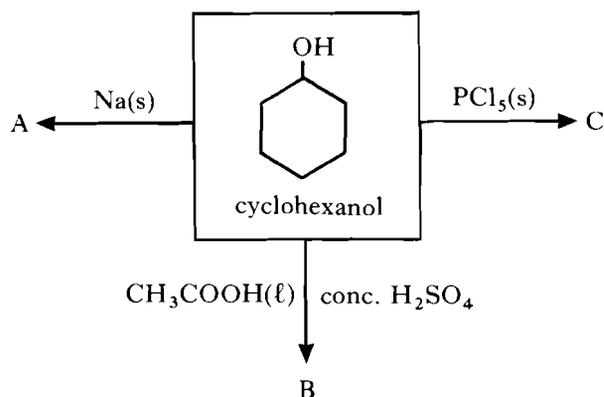
(b) What effect would an inhibitor have on

(i) the activation energy of the reaction in (a) (i); 1

(ii) the enthalpy change for the reaction in (a) (ii)? 1

(4)

13. Consider the sequence of reactions shown below:



Draw structural formulae for each of the organic products A, B and C.

(Formulae of the type shown for cyclohexanol will be acceptable.) (3)

14. (a) Using the table of Mean Bond Energies (Data Booklet, page 7), calculate the energy required to break one mole of chloromethane molecules into atoms in the gaseous state. 2

(b) Using your answer to (a) above and the enthalpy of sublimation of carbon (Data Booklet, page 7), calculate the enthalpy of formation of chloromethane. 3

(5)

PART B (48 marks)

All four questions should be attempted. It should be noted, however, that question 17 contains a choice.

Candidates are advised to spend about 1½ hours on this part of the paper.

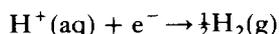
Marks

15. The Avogadro constant (N_A) may be estimated in a number of ways, two of which are described.

(a) Method 1 The electrolysis method.

Using platinum electrodes, a constant current is passed through dilute sulphuric acid.

The reaction at the negative electrode is:



From the experiment, the following are determined:

- (i) the mass of hydrogen produced (calculated from the volume collected);
- (ii) the quantity of charge which has produced this mass of hydrogen.

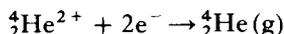
From (ii), the quantity of charge required to produce 1 gram (0.5 mole) of hydrogen may be calculated. Since each electron carries a charge of 1.6×10^{-19} coulombs, the number of electrons and hence a value for N_A can be found.

In such an experiment, the mass of hydrogen collected was found to be 2.48×10^{-3} g, using a current of 0.4 A for 10 minutes.

- (i) Calculate the quantity of charge passed during the experiment. 1
- (ii) Use the answer to (i) to find the charge required to produce 0.5 mole of hydrogen gas. 2
- (iii) Calculate the Avogadro constant. 2

(b) Method 2 The radioactivity method.

When a radioactive substance emits α -particles, helium gas is formed by the reaction:



A Geiger counter is used to count the number of α -particles emitted and, over a period of time, the volume of helium collected is measured.

In an actual experiment, a sample of radium-226 emitted 4.4×10^{10} α -particles **per second** over a period of 24 hours. The total volume of helium collected (at s.t.p.) was 1.40×10^{-4} cm³.

- (i) Write a nuclear equation for the disintegration of radium-226 by α -emission. 1
 - (ii) Use the Data Booklet to find the value for the half-life of the radioactive **product** obtained in (i). 1
 - (iii) How many α -particles were emitted during the 24 hour period? 1
 - (iv) How many moles of helium are present in 1.40×10^{-4} cm³ of the gas? 2
 - (v) Use your answers to (iii) and (iv) to calculate N_A . 2
- (12)**

16. Titanium is a widely used structural metal. The principal ore is rutile (TiO_2) which has a melting point of 2103 K.

The metal is extracted by first heating the rutile with coke (at 1000 K), in an atmosphere of chlorine, to form titanium(IV) chloride and carbon monoxide. (The boiling-point of titanium(IV) chloride is 409 K.) Titanium metal is then obtained from the chloride by reduction with magnesium in an atmosphere of argon.

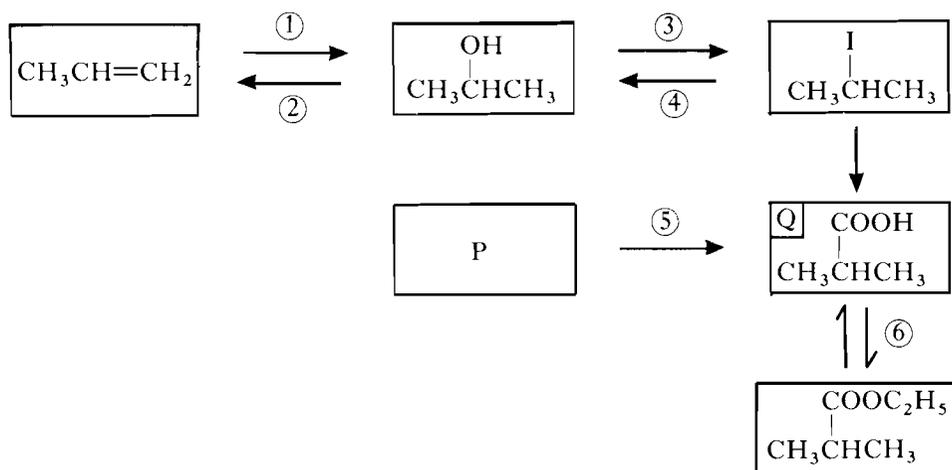
The properties of the metal include a high strength/weight ratio, a melting point of 1933 K and a high resistance to corrosion. The major uses of titanium are in jet engines, aircraft frames and submarines.

- (a) Write an equation for the formation of titanium(IV) chloride from rutile. 2
- (b) Suggest how the titanium(IV) chloride is separated from the carbon monoxide. 1
- (c) (i) Which type of bonding is present in titanium(IV) chloride? Quote evidence from the passage in support of your answer. 2
- (ii) Titanium(IV) chloride is hydrolysed by water. What are the products of this reaction? 1
- (d) Give **one reason in each case** why it is not practicable to obtain titanium electrolytically from
- (i) rutile;
- (ii) titanium(IV) chloride. 2
- (e) Give **two** properties of titanium which make it particularly suitable for the construction of submarines. 1
- (f) Suggest why sodium and calcium may also be used to reduce titanium(IV) chloride but iron is unsuitable. 1
- (g) Why is the reduction carried out in an atmosphere of argon? 1
- (h) Suggest why titanium(IV) oxide has largely replaced lead compounds as the major white pigment used in paint production. 1
- (12)**

[Turn over

17. Answer EITHER A OR B.

A. Examine the flow diagram and answer the questions which follow.

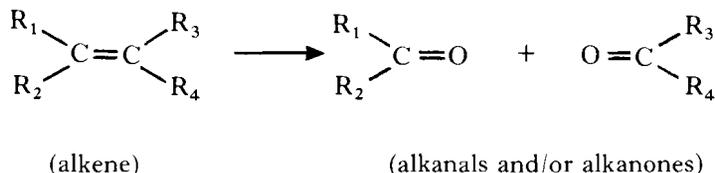


- (a) Compound P gives a silver mirror with ammoniacal silver nitrate (Tollen's reagent) and, in the process, is converted into Q. Name compound P. 1
- (b) State the types of chemical reactions involved in steps ①, ④, ⑤ and ⑥. 4
- (c) Name the reagents used in steps ② and ③. 2
- (d) Which additional organic reagent, not shown in the diagram, would be required for reaction ⑥? 1
- (e) One of the compounds in the flow diagram may be polymerised.
- (i) Name the polymer so formed. 1
- (ii) Draw part of the polymer structure, showing three monomer units linked together. 1
- (f) Nylon 6:10 may be produced from the compounds:
 $\text{H}_2\text{N}(\text{CH}_2)_6\text{NH}_2$ and $\text{HOOC}(\text{CH}_2)_8\text{COOH}$.
- (i) Name the type of chemical reaction involved. 1
- (ii) Draw part of the structure of nylon 6:10, showing three monomer units linked together. 1
- (12)**

OR

B. A gaseous compound X is known to be an alkene.

- (a) If 200 cm^3 of X (at s.t.p.) has a mass of 0.50 g , show by calculation that its molecular formula must be C_4H_8 . 2
- (b) Draw **full** structural formulae for **two** straight-chain alkenes and **one** branched-chain alkene having this molecular formula. 3
- (c) The position of the double bond in an alkene may be determined by a process called *ozonolysis*, in which the alkene is split (by ozone) at the double bond to give two carbonyl compounds:



where $\text{R}_1, \text{R}_2, \text{R}_3, \text{R}_4$ are hydrogen atoms **or** alkyl groups.

When the numbers and arrangements of carbon atoms in the products are known, the position of the double bond in the original alkene, and hence its structure, may be determined.

On ozonolysis, alkene X formed two compounds Y and Z. **Only Y gave a positive test with Benedict's (or Fehling's) solution.**

- (i) What would be **seen** to indicate a positive result in the Benedict's (Fehling's) tests? 1
- (ii) What do the actual test results indicate about the structures of carbonyl compounds Y and Z? 1
- (iii) From the information above, deduce which of the structures referred to in (b) is that of compound X. 1
- (iv) Name this isomer. 1
- (d) A **further** isomer of X belongs to a different homologous series from those referred to in (b). 1
- (i) Draw its full structure. 1
- (ii) Give its systematic name. 1
- (iii) Describe a test to distinguish this isomer from the others. 1
- (12)**

[Turn over

18. (a) The major reactions in three industrial processes may be represented as follows:

Process	Equation	Temp./ K	Press./ Atmos.	ΔH (forward)/ kJ
A	$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$	700	200	-92
B	$4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{g})$	1100	4	-909
C	$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$	700	1	-98

- (i) Name processes A and C. 1
- (ii) What is the source of hydrogen in process A? 1
- (iii) Justify the use of high pressure in process A but not in process B. 2
- (iv) Explain whether you think the temperatures employed in all these reactions are consistent with the enthalpy changes involved. 2
- (b) Ammonia may be used directly as a fertiliser, but it has been suggested that a more suitable substance for the purpose might be sodamide (NaNH_2), which reacts with water as follows:
- $$\text{NaNH}_2(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{NaOH}(\text{aq}) + \text{NH}_3(\text{g})$$
- (i) Give a reason why sodamide might be a more suitable fertiliser than ammonia. 1
- (ii) Explain why rivers might become polluted after absorbing sodamide from adjacent fields. 1
- (c) Most fertilisers contain the elements nitrogen, phosphorus and potassium, and are known as NPK fertilisers.
- In a fertiliser factory, a mixture of nitric acid and phosphoric acid (H_3PO_4) is neutralised with ammonia to give a mixture of ammonium nitrate and ammonium phosphate.
- (i) Write a balanced equation for the reaction, assuming that the molar ratio of nitric acid to phosphoric acid is 2:1. 2
- (ii) The solution is then evaporated to give a mixture of the two salts. Calculate the percentage by mass of nitrogen in the mixture. 2
- (12)**

[END OF QUESTION PAPER]